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ABSTRACT

This study examined differences in predicting achievement by sex on the Iowa Tests of Basic Skills (ITBS) from the verbal, quantitative, and nonverbal scores on the Cognitive Abilities Test (CogAT). The sample (n=10,000) consisted of all students in Grades 2, 5, and 8 who completed both tests in fall 1984. Examinations of means and standard deviations on CogAT showed that boys and girls had similar scores on all three CogAT areas for all grades. When ITBS scores were predicted separately from each CogAT score by sex, significant differences in either slope or intercept were found between the prediction equations for several ITBS subtests, most frequently for reading and language skills. The common regression lines for each ITBS subtest and CogAT score were computed by grade. The means and standard deviations of the residuals computed by sex showed consistent over-prediction for boys on the reading, reference materials, and language skills subtests. Girls' scores were consistently under-predicted on these subtests. These differences occurred even though average verbal, quantitative, and nonverbal ability measures were similar for boys and girls. Educators who use differences between actual ITBS achievement and expected achievement based on CogAT scores should be aware of the differences in prediction for boys and girls. (Author/PN)

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Differential Prediction of Academic Achievement
In Elementary and Junior High School By Sex

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Differential Prediction of Academic Achievement
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Abstract

The purpose of this study was to examine differences in predicting achievement by sex on the Iowa Tests of Basic Skills (ITBS) from the verbal, quantitative, and nonverbal scores on the Cognitive Abilities Test (CogAT). The sample consisted of all students in Grades 2, 5, and 8 who completed both the ITBS and CogAT in the Fall 1984 joint national standardization of ITBS Form G and CogAT Form 4, resulting in a sample of about 5000 boys and 5000 girls for each grade level.

Examination of means and standard deviations on CogAT showed that boys and girls had similar scores on all 3 CogAT areas for all grades. When ITBS scores were predicted separately from each CogAT score by sex, significant differences in either slope or intercept were found between the prediction equations for several ITBS subtests, most frequently for reading and language skills. The common regression lines for each ITBS subtest and CogAT score were computed by grade. The means and standard deviations of the residuals computed by sex showed consistent over-prediction for boys on the reading, reference materials, and language skills subtests. Girls' scores were consistently under-predicted on these subtests. These differences occurred even though average verbal, quantitative, and nonverbal ability measures were similar for boys and girls. Educators who use differences between actual ITBS achievement and expected achievement based on CogAT scores should be aware of the differences in prediction for boys and girls.

PURPOSE

The purpose of this study is to examine differences in predicting achievement by sex on the Iowa Tests of Basic Skills (ITBS) (Hieronymus, Hoover, and Lindquist, 1986 a, 1986 b) from the Verbal, Quantitative, and Nonverbal scores on the Cognitive Abilities Test (CogAT) (Thorndike and Hagen, 1985a, 1985b).

THEORETICAL FRAMEWORK

Predicted or anticipated achievement scores are commonly made available to school teachers and administrators with the results of standardized achievement testing. However, comparisons of the predictive validity for males and females at the elementary and junior high school levels are seldom provided. Examination of the research regarding sex differences in ability and academic achievement suggests that differences in prediction by sex are likely. Prior to adolescence few consistent differences in cognitive ability are found (Maccoby and Jacklin, 1974; Jensen, 1980; Denno, 1982), but during junior high school some consistent differences develop. The largest and most consistent difference is in spatial ability where males surpass females. Beginning in adolescence, females surpass males in many verbal abilities in general, while males show greater ability than females in quantitative areas. Denno notes that the sex differences on measures of cognitive ability tend to be small. When academic achievement rather than ability is considered, a somewhat different pattern appears. Stroud and Lindquist (1942) report that girls out-perform boys in all areas except mathematics.

Hilton and Berglund (1974) find significant differences in mathematics achievement by Grade 8 favoring boys, among students enrolled in the college preparatory program. In a study of students in grades 4 to 8, Lewis and Hoover (1983) find that girls consistently out-perform boys in language skills while boys gradually surpass girls in mathematics achievement during the junior high years. They report no significant differences between boys and girls in achievement on reading, vocabulary, and work-study skills. Martin and Hoover (1985) examine sex differences in achievement longitudinally. They report that females consistently surpass males in spelling, capitalization, punctuation, language usage, reading comprehension, reference materials, and mathematics computation. Males show superiority in visual materials and mathematics concepts. On vocabulary and mathematics problem solving they report no consistent differences. Based on the patterns described above, some differences in prediction for males and females seem likely.

METHOD

This study examines the prediction of ITBS subtest and total scores of elementary and junior high school boys and girls from their scores on CogAT. Grade equivalent scores are used for the ITBS, and standard age scores for the CogAT.

Sample. The sample consists of all students in Grades 2, 5, and 8 who completed both the ITBS and CogAT in the Fall 1984 joint national standardization of ITBS Form G and CogAT Form 4.

The sample is stratified by size of district, region of the country, and socio-economic status (SES) of the district. An equally weighted composite of median family income and median years education of adults over 25 years old in the school district based on 1980 census data was used to define SES. Any students with missing data were dropped from the analyses. The sample sizes by grade and sex are shown in Table 1.

TABLE 1
Sample Size by Grade and Sex

	<u>2</u>	<u>5</u>	<u>8</u>	<u>Total</u>
Boys	4623	5088	5085	14796
Girls	4712	5152	5148	15012
Total	9335	10240	10233	29808

INSTRUMENTS

Form 4 of CogAT consists of a primary battery for use in Kindergarten through Grade 3 and a multi-level edition for Grades 3 to 12. CogAT is intended to measure cognitive abilities related to verbal, quantitative, and nonverbal reasoning and problem solving. In the primary battery, verbal ability is measured by Oral Vocabulary and Verbal Classification subtests; quantitative ability by Quantitative Concepts and Relational

Concepts subtests; and nonverbal ability by Figure Classification and Matrices subtests. The primary battery requires no reading and is untimed. In the multi-level edition, verbal ability is measured by Verbal Classification, Sentence Completion, and Verbal Analogies. Quantitative ability is measured by three subtests: Quantitative Concepts, Number Series, and Equation Building. The Figure Classification, Figure Analogies, and Figure Analysis subtests are designed to measure nonverbal ability.

Form G of ITBS consists of an early-primary battery for use in Kindergarten and First Grade, a primary battery for use in the latter part of First Grade through Third Grade, and a multi-level edition for use in Grades 3 to 9. The ITBS subtests are designed to measure growth in the fundamental skills of listening, word analysis, vocabulary, reading, the mechanics of writing, methods of study, and mathematics (Hieronymus, Hoover, and Lindquist, 1986a, 1986b). The primary battery was used for Grade 2 and the multi-level edition for Grades 5 and 8 in this study. Consequently, the subtests taken by second grade students differ from the subtests taken by students in Grades 5 and 8. Administration of the tests also differs between the primary and multi-level edition. Several subtests are administered orally in the primary battery. The subtests are shown in Table 2.

The ITBS and CogAT are designed with different objectives. The ITBS are intended primarily to measure skills learned in school, while CogAT attempts to measure ability to work with

TABLE 2
Summary of ITBS Subtests

Abbreviation	Test	Administered Orally In Primary Battery
Li	Listening*	X
Wa	Word Analysis*	X
V	Vocabulary	
R	Reading	
	Language Skills:	
L1	Spelling	X
L2	Capitalization	
L3	Punctuation	
L4	Usage and Expression	X
LT	Language Total	
	Work-Study Skills:	
W1	Visual Materials	X
W2	Reference Materials	X
WT	Work-Study Total	
	Mathematics Skills:	
M1	Concepts	X
M2	Problem Solving	X
M3	Computation	X
MT	Mathematics Total	
CC	Composite	

* Listening and Word Analysis are not included in the multi-level edition.

ideas and symbols. It has been suggested that CogAT and ITBS may actually measure the same constructs (Sax, 1984). In particular, the CogAT subtests, Verbal Classification, Sentence Completion, Quantitative Concepts, and Equation Building, seem to cover somewhat similar content as the ITBS Vocabulary and Mathematics Concepts subtests. However, reported reliabilities of differences between actual and average ITBS performance for pupils of similar CogAT scores are substantial (Hieronymus, Lindquist, and Hoover, 1982). For composite scores on ITBS these reliabilities range from 0.70 (Verbal standard age score in Grade 8) to 0.91 (Nonverbal standard age score in Grade 3). Such values indicate that ITBS and CogAT are not measuring the same construct(s). It should be kept in mind that if one of the main purposes of combined ability-achievement testing is the identification of discrepant performance on these batteries, then these reliabilities are the variables of interest, not the correlations between ITBS and CogAT. As indicated above, these reliabilities are greatest when Nonverbal CogAT scores are used for prediction and least when Verbal scores are used.

ANALYSES

Summary statistics including means, standard deviations, and ranges were computed using the MEANS procedure from the Statistical Analysis System (SAS) (SAS Institute, 1982).

Differential prediction for boys and girls can be detected by statistically significant differences in slopes or intercepts from the separate regression lines for boys and girls (Jensen,

1980). Cleary (1968) states that a test is biased toward a subgroup of examinees if the predicted score from the common regression line is consistently too high or too low for members of the subgroup. Based on these methods, regression equations for each of the ITBS subtests on each of the three CogAT scores were computed separately for boys and girls using the SAS procedure, REG. The resulting slopes and intercepts were compared as suggested by Jensen. The common regression lines were also computed using REG. Means and standard deviations of the residuals from the common regression lines were computed separately by sex.

RESULTS

The means and standard deviations of the three CogAT scores, shown in Table 3, are very similar for boys and girls in each grade. However, the means for boys and girls on the Reading, Language Skills, and Reference Materials subtests of the ITBS show increasing differences across grades, with girls having larger scores in these areas. The means and standard deviations for the ITBS are shown in Table 4.

The regression equations run separately for boys and girls show significant differences between the slopes and/or intercepts of the regression lines for some of the ITBS subtests in each grade. The regression lines for Vocabulary and Language Skills are different most often. See Table 5.

The means and standard deviations of the residuals for boys

TABLE 3
CogAT Means and Standard Deviations
By Grade and Sex

	<u>Tests</u>		
	<u>Verbal</u>	<u>Quantitative</u>	<u>NonVerbal</u>
<u>Grade 2</u>			
Girls	100 (14)*	102 (16)	102 (15)
Boys	102 (14)	102 (17)	99 (15)
<u>Grade 5</u>			
Girls	103 (15)	101 (15)	100 (15)
Boys	101 (17)	101 (17)	100 (16)
<u>Grade 8</u>			
Girls	101 (15)	100 (14)	101 (13)
Boys	101 (16)	101 (16)	101 (14)

* Standard deviations are in parentheses.

TABLE 4
ITBS Means and Standard Deviations
By Grade and Sex

<u>Test</u>	<u>Grade</u> <u>2</u>		<u>Grade</u> <u>5</u>		<u>Grade</u> <u>8</u>	
	<u>Girls</u>	<u>Boys</u>	<u>Girls</u>	<u>Boys</u>	<u>Girls</u>	<u>Boys</u>
Li	23 (10)*	22 (10)				
Wa	23 (10)	22 (10)				
V	23 (9)	22 (9)	53 (14)	53 (15)	82 (18)	84 (19)
R	24 (10)	22 (10)	55 (14)	52 (16)	86 (19)	81 (21)
L1	25 (11)	22 (10)	56 (15)	51 (16)	88 (21)	79 (23)
L2	24 (10)	22 (9)	55 (15)	52 (16)	87 (23)	82 (24)
L3	25 (12)	23 (11)	56 (16)	52 (16)	87 (22)	80 (23)
L4	25 (13)	23 (13)	55 (18)	52 (18)	88 (22)	80 (24)
LT	25 (9)	22 (9)	56 (14)	52 (14)	88 (19)	80 (20)
W1	23 (10)	23 (11)	52 (14)	53 (16)	82 (19)	83 (21)
W2	24 (9)	22 (9)	54 (14)	52 (15)	87 (19)	80 (22)
WT	23 (9)	22 (9)	53 (13)	52 (15)	85 (18)	81 (20)
M1	22 (7)	23 (8)	53 (12)	53 (13)	84 (17)	84 (18)
M2	22 (9)	23 (9)	52 (13)	53 (14)	82 (17)	82 (19)
M3	22 (6)	22 (6)	53 (9)	51 (10)	84 (14)	80 (14)
MT	22 (6)	23 (7)	53 (10)	52 (11)	83 (14)	82 (15)
CC	23 (8)	22 (8)	54 (12)	52 (13)	84 (16)	82 (17)

* Standard deviations are shown in parentheses.

TABLE 5

Differences Between Regressions of
ITBS Subtests on CogAT Scores by Sex

Test	Grade 2						Grade 5						Grade 8					
	Slope			Intercept			Slope			Intercept			Slope			Intercept		
	V	Q	NV	V	Q	NV	V	Q	NV	V	Q	NV	V	Q	NV	V	Q	NV
L1	x	x	x		x	x												
Wa			x			x												
V			x			x							x			x		x
R	x		x			x							x	x		x	x	x
L1	x	x	x															
L2	x	x	x	x		x												
L3	x	x	x	x	x	x	x	x		x								
L4		x	x		x	x	x									x	x	x
LT	x	x	x	x	x	x	x		x							x		
W1																		
W2			x										x		x	x	x	x
WT			x			x										x	x	x
M1							x	x		x	x							
M2						x	x		x	x	x							
M3		x			x													
MT																		
CC	x	x	x			x												

and girls from the common regression line are shown in Tables 6 and 7. Here the under-prediction of Reading, Reference Materials, and Language scores for girls (and the corresponding over-prediction for boys) is especially noticeable. In some areas the mean difference between actual and predicted scores is nearly 4 points which can be thought of as 4 months of school since these are based on grade equivalents. The standard deviations of these residuals tend to become larger across grades, and, especially in eighth grade, the standard deviations are larger for boys.

DISCUSSION

In this group of students, the average scores of boys and girls on all three CogAT tests are very similar. Thus, the differences which appear on the ITBS do not seem to be due to differences in measured verbal, quantitative, or nonverbal ability. Rather, these ITBS results may reflect differences in what boys and girls learn in school.

When CogAT scores are used to compute predicted ITBS scores, girls' scores on the Language, Reading, and Reference Materials subtests are under-predicted, and boys' scores in these areas are over-predicted. If students are chosen for special programs on the basis of discrepancies between predicted and obtained achievement, boys will be chosen more frequently for programs where "underachievement" (over-prediction) is the criteria. Likewise, girls will be over-selected when these discrepancies

TABLE 6

Mean Residuals for Girls* from Regression
Of ITBS on CogAT for the Total Group

Test	Grade:	V			Q			NV		
		<u>2</u>	<u>5</u>	<u>8</u>	<u>2</u>	<u>5</u>	<u>8</u>	<u>2</u>	<u>5</u>	<u>8</u>
Li		.6			.4			.0		
Wa		.8			.5			.1		
V		.6	-.6	-.9	.4	.1	-.7	.1	-.1	-.9
R		1.3	.5	2.3	1.1	1.2	2.5	.7	1.1	2.3
L1		1.3	2.3	4.4	1.5	3.0	4.6	1.2	2.8	4.5
L2		1.0	1.3	2.7	.9	1.9	2.9	.6	1.8	2.7
L3		1.4	1.7	3.8	1.3	2.4	4.0	.8	2.2	3.8
L4		1.5	1.2	3.6	1.2	2.1	3.8	.7	1.9	3.6
LT		1.4	1.6	3.7	1.2	2.3	3.9	.8	2.2	3.7
W1		.3	-.8	-.4	.1	-.1	-.2	-.3	-.3	-.5
W2		1.2	.7	3.5	1.0	1.4	3.7	.6	1.2	3.5
WT		.8	-.1	1.5	.6	.6	1.7	.1	.5	1.5
M1		-.2	-.5	-.1	-.4	.1	.1	-.7	-.1	-.1
M2		-.1	-.9	-.4	-.3	-.3	-.3	-.6	-.4	-.4
M3		.3	.6	2.0	.2	.9	2.1	.0	.8	2.0
MT		.0	-.3	.5	-.1	.2	.6	-.5	.1	.5
CC		.8	.2	1.4	.6	.9	1.6	.2	.8	1.4

* The mean residuals for boys are approximately the same magnitude as those for girls but with the opposite sign.

TABLE 7

Standard Deviations of Residuals by Sex
From Regression of ITBS on CogAT for the Total Group

Test	Grade:	V			Q			NV		
		2	5	8	2	5	8	2	5	8
L1	F	8.0			8.0			8.7		
	M	7.8			7.9			8.5		
Wa	F	8.3			8.0			8.7		
	M	8.4			8.0			8.8		
V	F	7.5	8.6	10.5	7.3	10.8	14.5	7.9	11.5	15.2
	M	7.8	8.9	10.8	7.5	11.3	14.5	8.3	12.0	15.7
R	F	8.2	8.5	11.8	8.0	10.4	13.9	8.5	11.0	15.0
	M	8.4	9.3	13.6	8.0	11.3	15.5	8.8	12.1	17.0
L1	F	9.5	11.5	16.6	9.3	12.4	17.7	9.6	13.4	18.8
	M	9.3	11.7	17.3	9.1	12.7	18.4	9.3	13.9	20.3
L2	F	8.8	12.0	16.9	8.7	12.2	17.9	8.9	12.6	18.7
	M	8.6	12.4	18.7	8.3	12.2	18.9	8.6	12.8	19.7
L3	F	10.2	12.4	16.1	9.9	12.6	16.9	10.2	12.9	17.6
	M	9.7	12.2	17.1	9.4	12.2	17.1	9.7	12.5	18.1
L4	F	11.3	11.4	14.3	10.9	13.1	16.4	11.9	13.8	17.5
	M	11.1	11.5	15.3	10.8	13.2	17.1	11.7	14.1	18.7
LT	F	7.4	9.0	12.0	7.1	9.9	13.7	7.7	10.7	14.8
	M	7.2	9.0	13.0	6.8	9.7	13.9	7.4	10.7	15.6
W1	F	8.4	10.0	13.2	8.0	10.2	13.5	8.8	10.5	13.8
	M	8.7	11.0	14.4	8.3	11.2	14.2	9.3	11.5	15.1
W2	F	7.4	9.6	13.7	7.3	10.1	14.0	7.8	10.6	14.8
	M	7.4	10.2	15.8	7.2	10.7	15.0	7.7	11.5	16.8
WT	F	6.9	8.6	11.5	6.7	8.9	11.8	7.4	9.4	12.6
	M	7.2	9.2	13.2	6.8	9.6	12.9	7.7	10.3	14.1
M1	F	5.9	9.0	11.9	5.3	8.3	10.6	6.0	9.0	12.0
	M	6.6	9.7	13.2	5.6	8.6	11.4	6.7	9.8	13.2
M2	F	7.5	9.5	12.7	6.7	9.0	11.6	7.7	9.9	12.8
	M	7.9	9.8	13.6	6.9	9.2	12.1	8.2	10.2	14.0
M3	F	5.8	8.3	11.6	5.5	7.6	10.5	5.7	8.2	11.2
	M	5.9	8.7	12.7	5.5	7.8	11.2	5.8	8.6	12.3
MT	F	6.2	7.1	9.8	4.4	6.2	8.3	5.2	7.1	9.7
	M	6.3	7.6	11.0	4.6	6.4	8.9	5.7	7.7	10.8
CC	F	5.6	6.1	7.8	5.2	7.4	9.6	6.1	8.2	10.9
	M	5.7	6.5	8.9	5.2	7.7	10.2	6.2	8.8	11.9

indicate "overachievement" (under-prediction). Parent and teacher expectations based on the predicted scores may be too high for boys and too low for girls in language-related areas.

Finally, Sax (1984) suggests that the Verbal score alone may be sufficient for predicting achievement. If accurate prediction is the purpose of the combined CogAT and ITBS testing, then a combination of Verbal and Quantitative scores would be the best choice for predictor. However, if the purpose of the testing is to identify areas in which students' obtained scores differ from their predicted scores, then the Nonverbal score would be the best choice. The Nonverbal test has little overlap with the ITBS subtests and has the lowest correlation with the subtest scores. In addition, the reliabilities of the differences between actual and average ITBS scores for students with similar CogAT scores are somewhat larger for the Nonverbal test (Hieronymus, Lindquist, and Hoover, 1982).

In summary, when CogAT scores are used to predict ITBS achievement, girls' scores on the Reading, Reference Materials, and Language subtests are over-predicted and boys' scores under-predicted. These differences occur even though average verbal, quantitative, and nonverbal abilities are similar for boys and girls. Teachers and administrators who use these scores to interpret student scores or to select students for particular programs should be aware of the differences in prediction in language-related areas for boys and girls.

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